PROGRESS REPORT
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Project Title: Predicting North American Monsoon Rainfall Using Mesoscale Modeling with an Emphasis on Satellite Data Assimilation (2004-2007)
Project Number: GC04-173
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In 2004, we made significant progress on the proposed studies. The major goal of this proposal is to develop scientific understanding of the North American Monsoon System (NAMS) leading to more realistic simulation and prediction of monsoon rainfall with an emphasis on the use of satellite and NAME *in situ* data. The research strategy of this proposal includes three interacting constituents, namely: (1) a coupled atmosphere-land surface mesoscale model; (2) satellite remotely sensed products; and (3) the NAME *in situ* observations and measurements. We report our 2004 research achievements according to these three issues as follows.

1. Mesoscale Modeling System

We have completed two monsoon modeling research studies. One studied the long-term characteristics of NAM in numerical simulation: Model climatology of the North American monsoon onset period during 1980-2001 (Xu et al, 2004). This was a unique multi-decades (22 years) simulation. The comparison between model simulations and observations shows that the model simulation reproduces the precipitation, skin temperature, and wind field patterns in the seasonal development (May-July) of the NAMS reasonably well, and that the mesoscale features and spatial heterogeneity of the NAMS are described correctly. Onset of the monsoon in the central and southern Sierra Madre Occidental (SMO) in Mexico occurs on June 20, about two weeks earlier than the onset in Sonora, Mexico (July 6), the Sonoran Desert, and central Arizona and New Mexico (July 8). The temperature in Mexico is highest after the onset of the monsoon and then decreases with the increasing monsoon rainfall. However, the temperature in the Sonoran Desert and central Arizona and New Mexico is highest just prior to the onset of the monsoon, and high temperatures may then persist throughout July. The lower level (700 hPa) zonal wind field reverses from westerly to easterly over the central and southern SMO just before the onset of rain in these regions, this being associated with the abrupt northward movement of the subtropical high over this region. The progression of the subtropical high into central Arizona and New Mexico results in a local reduction in the westerly flow and, although the southwesterly flow weakens, atmospheric moisture is still mainly from the Gulf of California and the eastern Pacific Ocean.

In the second study, we conducted the model study for the evolution and diurnal variations of rainfall in North American monsoon during June and July 2002 (Li, et al, 2005). This paper indicates that the rainfall timing evolution in the monsoon core region predicted by the model generally matched the gauge observations, however, the differences among the three precipitation estimates (model, satellite, and gauge) are obvious, especially in July. The rainfall diurnal cycle pattern was reproduced in the monsoon core region of western Mexico, but there were differences in the diurnal intensity and timing between modeled and observed results. Furthermore, the model cannot capture the diurnal variation over Arizona.

Modeling results showed heavy monsoon rains shift northward along the western Mexico coast in association with the northward shifts of the subtropical highs. This is consistent with previous data analyses. The rainfall diurnal cycle was associated mainly with sea-land/mountain-valley circulations over western Mexico and adjacent oceans.

The simulations show that the model has deficiencies in predicting precipitation over the Gulf of Mexico. The model cannot reproduce the low-level inversion above the marine boundary layers and thus does not generate enough convective inhibition (CIN) to suppress the convection. The model also cannot produce realistic variations of day-to-day atmospheric conditions with only a single initialization at the start of the month.

2. PERSIANN Precipitation Data for the Monsoon Rainfall Monitoring

By using the newly developed Cloud-Classification Scheme (CCS, Hong et al., 2004), the PERSIANN monsoon rainfall for 2003-2004 at improved spatial and temporal resolutions of 12 km and hourly have been produced over the NAM core region including the tropical Pacific ocean, southern and northwestern Mexico and southwestern United States. Because of the delay of the NAME in situ data, we were unable to compare the PERSIANN rainfall data with the ground observations and analyze the PERSIANN rainfall errors, also we were unable to use merge technologies to produce the better-quality monsoon rainfall data using combined information sources, as proposed in the project. As soon as the NAME observation data are available, we will conduct the error analysis and merge study immediately. Our study has been focused on monitoring monsoon rainfall evolution from ocean to land from the satellite remote sensing. We are currently producing real-time hourly 0.25° PERSIANN rainfall data for the monsoon region, these data can be view and download from the web site (http://hydis8.eng.uci.edu)

3. Data Assimilation

We have practiced rainfall assimilations using the MM5-4DVAR system A short paper, "Investigate the impacts of assimilating satellite rainfall estimates on rainstorm forecast over southwest United States" which summarized the results was published in the Geophysical Research Letters (Xu et al 2004). In this case study, a monsoon rainstorm over southern Arizona (5-6 August 2002) was investigated for the influence of assimilating satellite rainfall estimates on precipitation forecasts. A set of numerical experiments was conducted with multiple configurations including using 20-km or 30-km grid distances and none or 3-h or 6-h assimilation time windows. Results show that satellite rainfall assimilation can improve the rainstorm-forecasting pattern and amount to some extent. The minimization procedure of 4DVAR is sensitive to model spatial resolution and the assimilation time window. The 3-h assimilation window with hourly rainfall data works well for the 6-h forecast, and for 12-h or longer forecasts, a 6-h assimilation window will be requested.

References

Li, J., X. Gao, R.A. Maddox, and S. Sorooshian, Model study of evolution and durnal variations of rainfall in North American monsoon during June and July 2002, *Mon. Wea. Rev.*, 132, 191-211, 2004.

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